INTEGRATED OF STEPPER AND DC MOTOR **CONTROL SYSTEM USING MICROCONTROLLER FOR AUTOMATIC DISHWASHER**

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Abstract. Control system is one of the important applications in automation application. The purpose of the control system in industrial field is to control the flow of the process in part of machine operation. This paper is presented a design for automatic dishwasher utilizing stepper and DC motor control system. The control system in machining process is created by using PLC programmed setup and it is transfer to the higher memory capability chip inside the microcontroller which is microchip ULN2803. The robotic arm, cleaning brush, and water pump which is fully automatic function is totally conducted by the stepper and DC motor.

Keywords: **Control system,** Stepper motor, DC motor and microcontroller

1. INTRODUCTION

In the market, it is a lot of motor utilization in industrial application or development of electrical product. The main functions of motors are for pumping fluids, compressors, driving conveyer belts, and any form of positioning required in industry. For control application or positioning, servos or stepper motors are used. The utilization of motor also used in automotive manufactured such as wiper mechanism and side window control. This mechanism is controlled by dc motor application. The control system for dc motor and stepper motor are different. Stepper motor can rotate by given the positioning angle or step. To control the dc motor is by giving direct current. That's mean the dc motor can't controller the sequence of rotational angle. To control the device such as dc and stepper motor application of microcontroller is require.

2.0 LITERATURE REVIEW

The literature below will go through the stepper and DC motor application together with microcontroller utilization.

2.1 STEPPER MOTOR APPLICATION

Stepper motor functions by rotate at a fixed angle with each input pulse. Normally, the rotor is fixed magnet with several poles and a stator with several windings.

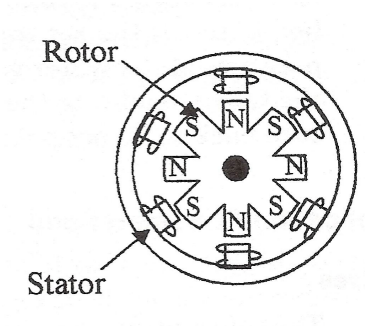

Figure 1: Stepper motor systems

Figure 1 shows that inner system of stepper motor have eight magnetic poles and six-section stator. They have many design of stepper motor in the market with a wide section of the number of poles and driven requirement, all of which define the stepper motor characteristics and rotation angle for each input phase. The reversed process in stepper motor can be applied by changing the sequence of the driving phases. Stepper motors are available with stepping angles of 0.9, 1.8, 3.6, 7.5, 15, and 18 degrees. Since the motor steps a known angle with each input pulse, feedback is not required. In the stepper motors application, position reference is usually required. It's because only the relative position is known, loss of power will cause loss of position information. [1]

Referring to Figure 2, to rotate the shaft, each magnetic field must be energized in such a sequence that will make the shaft repel or attract to the magnetic field.

Figure 2: Unipolar stepping motor type.

In market area have many type of stepper motor. Figure 2 describes about the system of creating magnetic field around six magnets. That's mean to control the stepper motor energized must be given to all six coordinate of coil to control the rotation of stepper motor. Figure 3 show the sequence of unipolar stepper motor rotate by given energy to all side of magnetic field.

Figure 3: Sequence of 4 magnetic field of stepper motor.

2.2 DC MOTOR APPLICATION

The direct current (DC) motor is one of the first machines devised to convert electrical power into mechanical power. Permanent magnet (PM) direct current converts electrical energy into mechanical energy through the interaction of two magnetic fields. One field is produced by a permanent magnet assembly and the other field is produced by an electrical current flowing in the motor windings. These two fields result in a torque which tends to rotate the rotor. As the rotor turns, the current in the windings is commutated to produce a continuous torque output. The stationary electromagnetic field of the motor can also be wire-wound like the armature (called a wound-field motor) or can be made up of permanent magnets (called a permanent magnet motor). [2]

Motor speed control of DC motor is nothing new. A simplest method to control the rotation speed of a DC motor is to control its driving voltage. The higher voltage is the higher speed of motor tries to reach. In many applications a simple voltage regulation would cause lots of power lessons control circuit, so a pulse width modulation method (PWM) is used in many DC motor controlling applications. In the basic Pulse Width Modulation (PWM) method, the operating power to the motors is turned on and off to modulate the current to the motor. The ratio of "on" time to "off" time is what determines the speed of the motor. When doing PWM controlling, keep in mind that a motor is a low pass device. The reason is that a motor is mainly a large inductor. It is not capable of passing high frequency energy, and hence will not perform well using high frequencies. Reasonably low frequencies are required, and then PWM techniques will work. Lower frequencies are generally better than higher frequencies, but PWM stops being effective at too low a frequency. The idea that a lower frequency PWM works better simply reflects that the "on" cycle needs to be pretty wide before the motor will draw any current (because of motor inductance). A higher PWM frequency will work fine if you hang a large capacitor across the motor or short the motor out on the "off" cycle (e.g. power/brake pwm). The reason for this is that short pulses will not allow much current to flow before being cut off. Then the current that did flow is dissipated as an inductive kick - probably as heat through the fly back diodes. The capacitor integrates the pulse and provides a longer, but lower, current flow through the motor

after the driver is cut off. There is not inductive kick either, since the current flow isn't being cut off. Knowing the low pass roll-off frequency of the motor helps to determine an optimum frequency for operating PWM. Try testing your motor with a square duty cycle using a variable frequency, and then observe the drop in torque as the frequency is increased. This technique can help determine the roll off point as far as power efficiency is concerned.

2.3 MICROCONTROLLER APPLICATION

Microcontrollers are general purpose microprocessors which have additional parts that allow them to control external devices. Basically, a microcontroller executes a user program which is loaded in its program memory. PIC Microcontroller is one of the famous types of microcontroller usage in development controlling device.

3.0 METHODOLOGY

The guideline for methodology section the elaboration of information from the literature review section. This section will describe the specification of microcontroller application in order to control the stepper and dc motor device. Microcontroller can make the device by running automatically.

3.1 PIC MICROCONTROLLER

To control the device such as stepper and dc motor, application of PIC Microcontroller is very important. PIC Microcontroller is operation like an electric circuit and useful to control many device in one circuit by given the sequence of process. That's mean, the process follow through step by step. For example the first step is movement counter clockwise of dc motor, second step is the rotation of stepper motor. From the direction given, the process can be controlled automatically and make the user easier to use it compare to manual handling by control the on off button. The suitable microcontroller chosen for control the stepper and dc motor is the emBOX-877 microcontroller. This microcontroller also known as 3-in1 PIC 16F877A Starter kit and the world smallest and it is only 6.5cm x 3.81 size. It comes with a very neat plastic enclosure to house this board. emBOX-877 comes with a bootloader and it does not require an external programmer.

3.2 PROGRAMMING SETTING

The main objective by using the PIC microcontroller with the programming setting is control the movement the stepper and dc motor to rotate counter clockwise or clockwise. All the cording inside the programming system has specification function such as to stop the process and delay the time operation. The process is also must be considered to make the sequence of the process is smoothly and suitable.

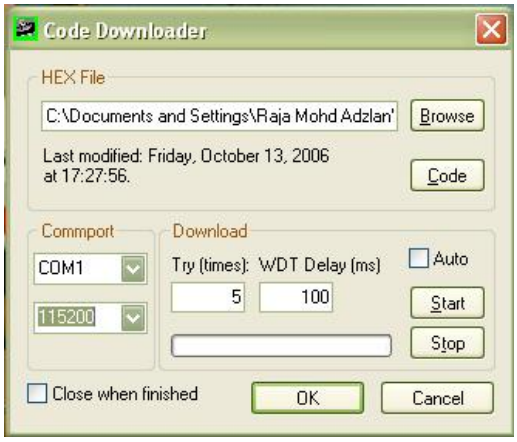

Figure 4: CD2M Bootloader

The program must be use to setup the operation in PIC Microcontroller is PIC C Compiler software. This software is quite similar to C++ programming. The cording must be setting in and compile to detect whether the programming is true or have a failure in this software.

After that the programming must be downloaded in PIC Microcontroller by using CD2M Bootloader program shown in Figure 4. The programming is in .cof or .HEX file will transfer from PC to PIC Microcontroller by using RED serial RS 232 cable. Figure 5 below show the flow of the downloaded programming into PIC Microcontroller.

Figure 5: Downloaded programming into PIC Microcontroller

3.3 PROGRAMMING SETTING

The 33 I/0 port pins in emBOX-877 are coming out via sockets which provide easy connection to external Bread-board using wires. Totally this type of PIC Microcontroller has four ports available connection to any device. To control the device smoothly, the determination of pin at all ports is very important.

Figure 6 shows the diagram of all pins at all port in this PIC Microcontroller which is port A, B, C and D. to

determined the port is available, the diode is placed at all pin and the cording must be try one by one. Table 1 shows the total of all pin at any port in PIC Microcontroller type emBOX-877.

Table 1: Determination of port in PIC Microcontroller

Port	Total Pin
A	6
B	7
C	7
D	8

Figure 6: Port of PIC Microcontrollers

4.0 RESULT AND DISCUSSION

4.1 STEPPER MOTOR CONNECTION

Different stepper motors have difference connection of wire to control it by using PIC Microcontroller. Figure 7 shows the connection wire for stepper motor 12V.

The schematic diagram of the stepper motor is shown in Figure 7. Usually, the wires that come out from stepper motor are of different colors and each color represent specific coil position. To determine the specific coil position for this wire, Digital Multimeter has use referring from the value of current flow. Left hand side is no connection with right hand side diagram. This unipolar motor has red, brown, black yellow and orange wire. The red wires in stepper motor are connected to the 12 V power supply while the rest of the wires are connected to motor driver. To reverse the motor direction from clockwise to counterclockwise, give the sequence direction from sequence 4 to sequence 1.

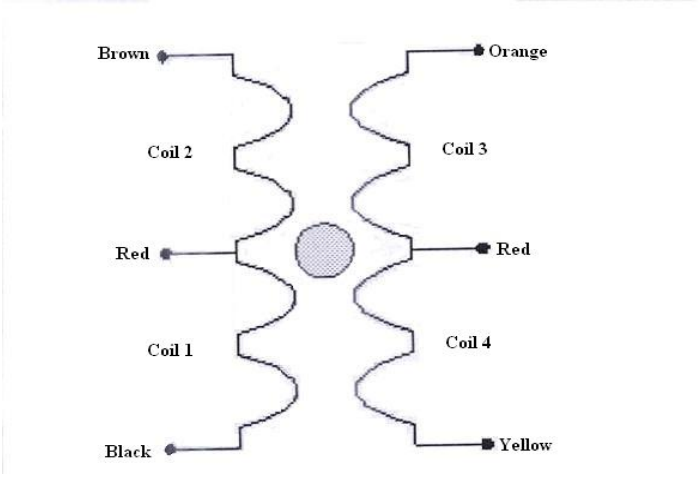

Figure 7: Connection wire of stepper motor

Energize sequence	Stepper Motor Wire					
	Red	Red	Orange	Yellow	Brown	Black
1	12V	12V	ON	OFF	ON	OFF
2	12V	12V	OFF	ON	ON	OFF
3	12V	12V	OFF	ON	OFF	ON
4	12V	12V	ON	OFF	OFF	ON

Table 1: Sequence given for stepper motor

All kind of stepper motor has different degree per step. This is important to control the loop of stepper motor rotation in PIC C Compiler software by cording given. Stepper motor 1 has 7.5 degree per step. Calculation below had shown how to get the value of loop for each motor. The cording given to rotate the stepper motor always the same.

To control the stepper motor in port A, cording 'portA' is given. To use another port just declare the port in the cording. The function delay is given to control the speed of the stepper motor after finish this operation, another operation will be run. The loop declaration in calculation below is depending on total degree of the rotation movement in stepper motor movement. The sequence is different if the motor will move in the different degree of rotation. So to determine it, put the value of the degree in calculation below.

Loop calculation for stepper motor 1(rotate 360():

7.5 degree	=	1 step
360 degree	=	360 x 1 / 7.5
	=	48 step
4 step	=	1 sequence
48 step	=	48 x 1 / 4
	=	12 sequence

Loop calculation for stepper motor 2(rotate 180():

1.8 degree	=	1 step
180 degree	=	180 x 1 / 1.8
	=	100 step
4 step	=	1 sequence
100 step	=	100 x 1 / 4
	=	25 sequence

4.2 DC MOTOR CONNECTION

The main purpose by using relay in this project is to cut off the flow current from direct to the device and to switch the current flow from one side to another side. Relay application is use to control the rotation of the dc motor from counter clockwise to clockwise movement. The connection of relay to dc motor is shown in Figure 8.

Figure 8: Two relays combine to dc motor

By giving the current on first pin in relay application, the dc motor will rotate counter clockwise. The dc motor will change the rotation to clockwise movement when current given in second pin in relay application. The process of current transfer is controlled by PIC microcontroller.

4.3 MICROCHIP COMPONENT

There have many type of microchip component in market area. ULN2803 microchip type will use as shown in Figure 9 in this project. This chip will help in getting the current needed to drive the motor or give current flow to water pump instead of taking it from PIC Microcontroller. The chip will drawn the current from 12V power supply.

Figure 9: Diagram of ULN2803 microchip

5.0 APPLICATION

Stepper and DC motor control system by using microcontroller is applied in new design of an automatic dishwasher for household application. The overall system is controlled by PIC microcontroller. The flow of washing process is differing from the previous design. New design of automatic dishwasher is using brush application and didn't use water heater system.

PIC Microcontroller system is similar with the usage of PC interface connected to the device circuit to control the device. But the difference between each system is in programming setup. PIC Microcontroller is programming by PIC C Compiler software. PC interface is programming by C++ software. The cording is quite similar but in some operation by the cording given is difference. The main objective by using PIC Microcontroller in this project is to setting the washing flow process by setting the sequence of the mechanical device inside new design of an automatic dishwasher one by one. Water pump 1 will on when the dc motor start rotate counter clockwise. The arrangement of water pump and dc motor is shown in Figure 11.The connection of water pump 1 and dc motor is the same place in device circuit. That's mean when the voltage was given at that port the devise will run together. The connection from device circuit to the device will controlled by PIC Microcontroller. Stepper motor 1 also will run when the dc motor rotate counter clockwise. Stepper motor 1 is combining with a span in brush application shown in Figure 10. The port to control the stepper motor 1 is not same with port of dc motor. The device can run together because the flow of current wills control by the programming in PIC Microcontroller. Delay 3 second will stop the current flow 3 second before flow again. So this process will stop the device from any operation. The second operation is also the same concept from the previous process. But the dc motor will rotate clockwise by using relay. Relay can change the current flow from one side to another side. Dc motor can't be controlled the step of movement compare to the stepper motor. The device will always on when given the current. The next step all the previous device will stop in 60 second. When the devices stop all operation plate holder controlled by stepper motor 2 will rotate 180(counter clockwise as a plate holder shown in Figure 10. This operation is to change the plate washing process to another side of dish. Hair dryer will on when the plate holder already change the position to dry the cleaned dish. In the same time, the washing process in surface dish area is repeated. That's mean the process is repeated two time in this system to cleaned both side of dirt plate.

Figure 10: Front view of new dishwasher design

Figure **11**: Back view of new dishwasher design

6.0 CONCLUSION

The connection of stepper motor is depending on their type and voltage usage. Different type use different colour of connection wire. So to determine the connection wire digital multi-meter usage is required before setting the movement of stepper motor.

To control the dc motor movement from counterclockwise to clockwise side, relay application is important. It is because dc motor is direct current flow and can't control the angle rotation.

7.0 REFERENCES

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PIC Microcontroller
(emBOX-877 microcontroller)

CD2M Bootloader

PIC C Compiler
Software

Coil 4

Coil 3

Coil 2

Coil 1

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